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Hirashima

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(54) SWITCHING POWER SUPPLY

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(30) **Foreign Application Priority Data**

Apr. 27, 2010 (JP) 2010-101805

(51) **Int. Cl.**
H05K 7/20 (2006.01)

(52) **U.S. Cl.**
USPC **361/689**; 361/690; 361/698; 361/699; 165/104.33; 165/80.4

(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

A switching power supply has electronic parts that configure a switching circuit. The electronic parts are accommodated in a casing. A seat member is formed unitarily with the casing on which the electronic parts are mounted. A coolant channel is formed through the seat member so as to be open at least at two positions of an outer wall surface of the casing. Coolant that flows through the coolant channel cools the electronic parts mounted on the seat member.

7 Claims, 12 Drawing Sheets

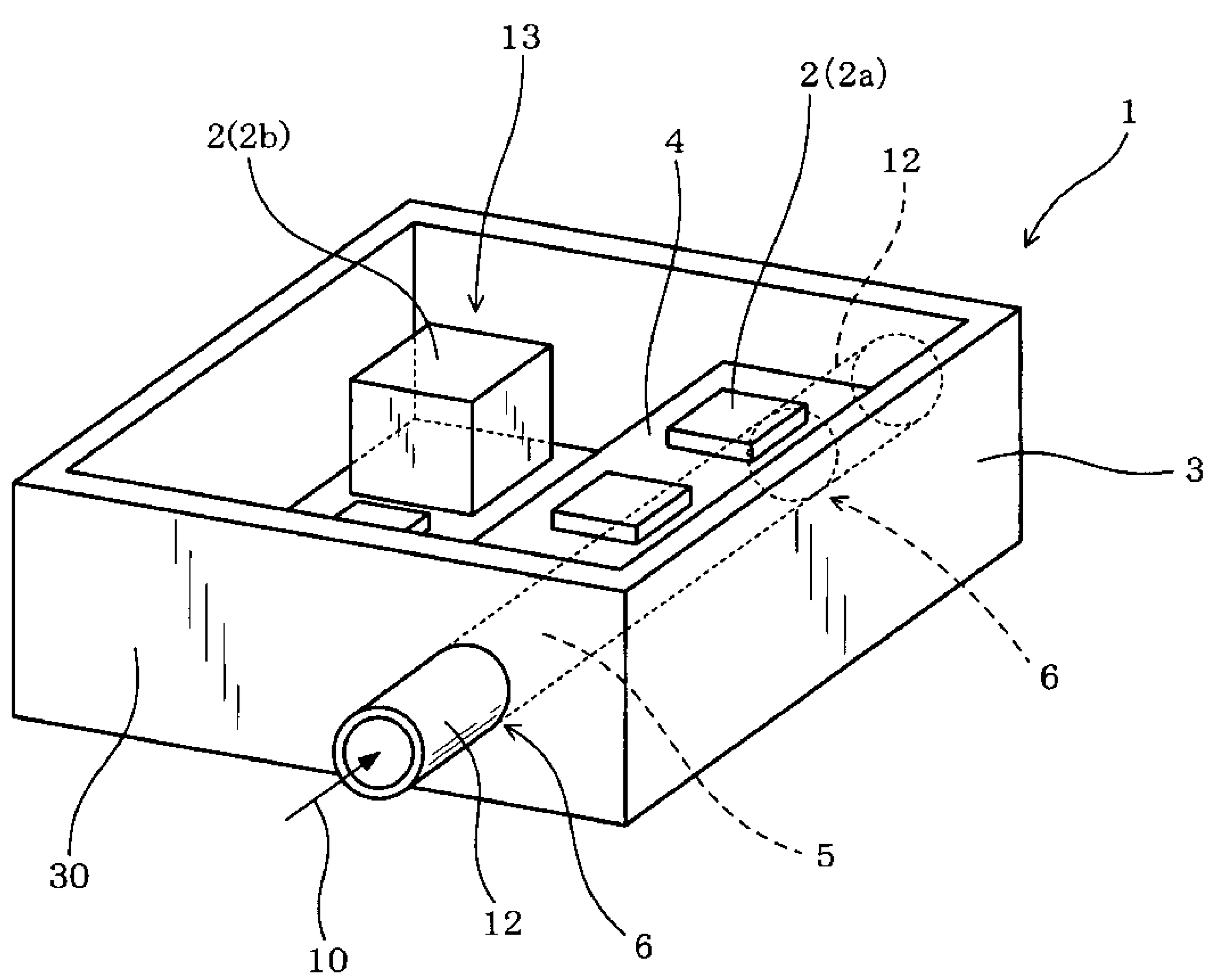


FIG. 1

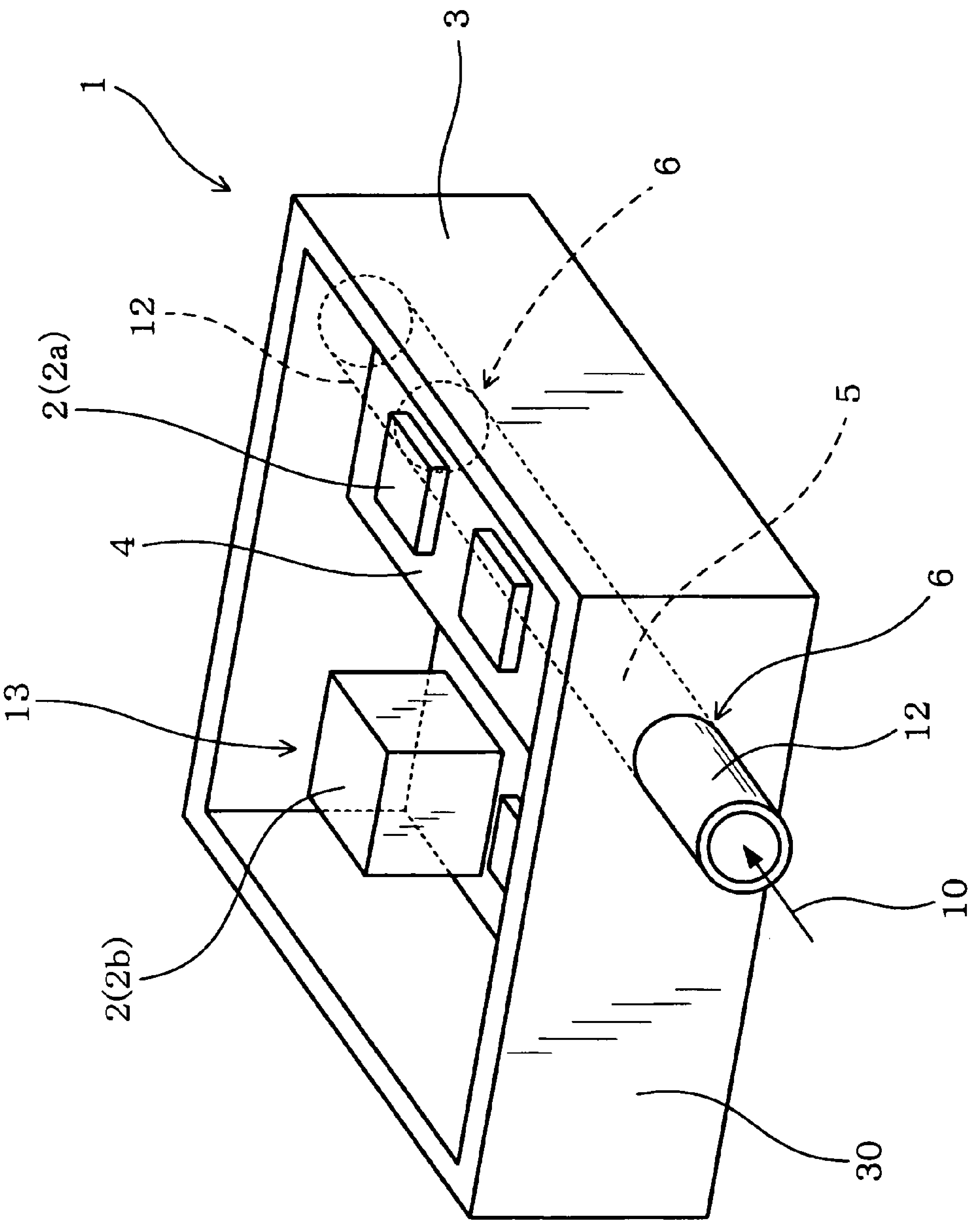


FIG.2

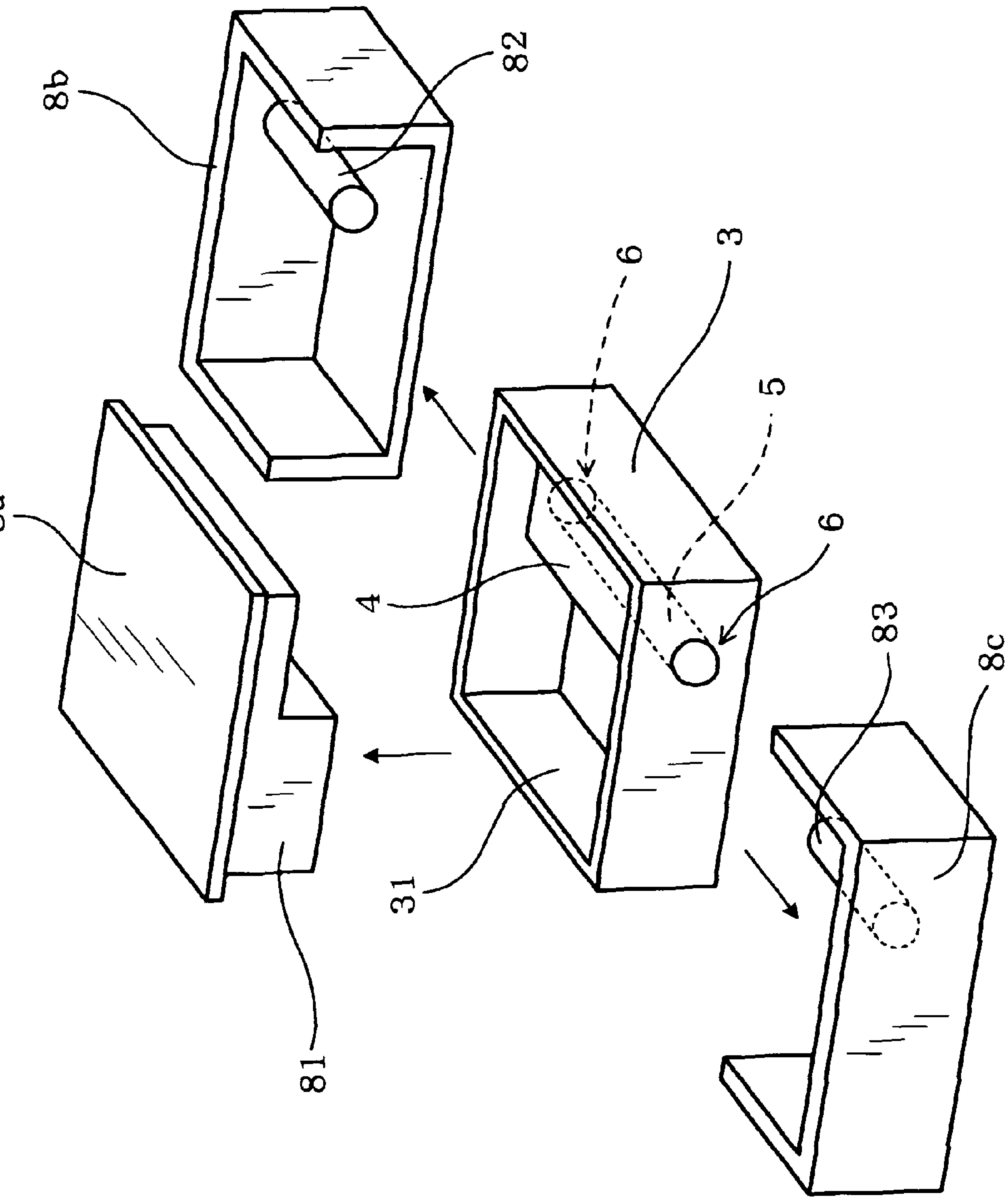


FIG.3

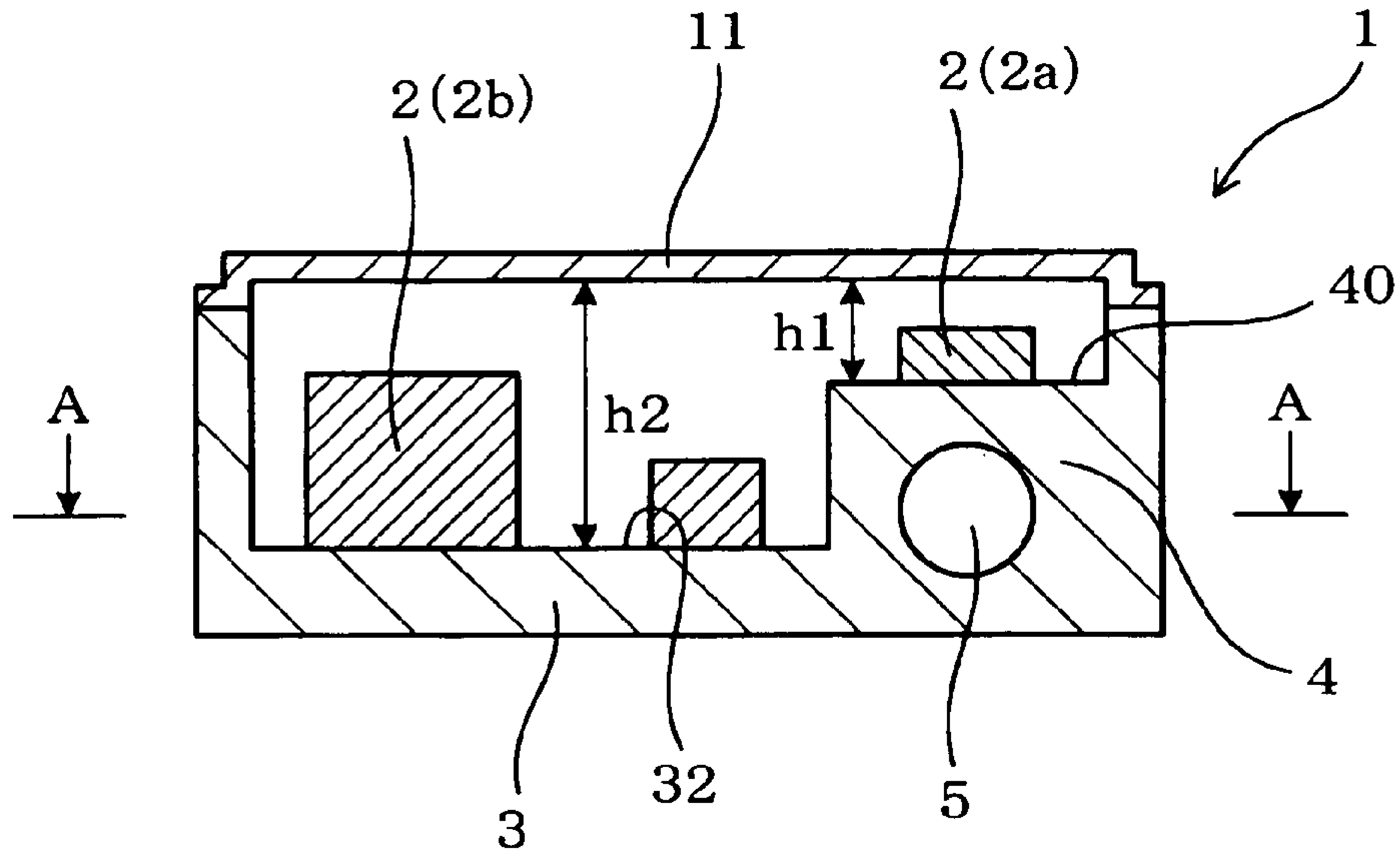


FIG.4

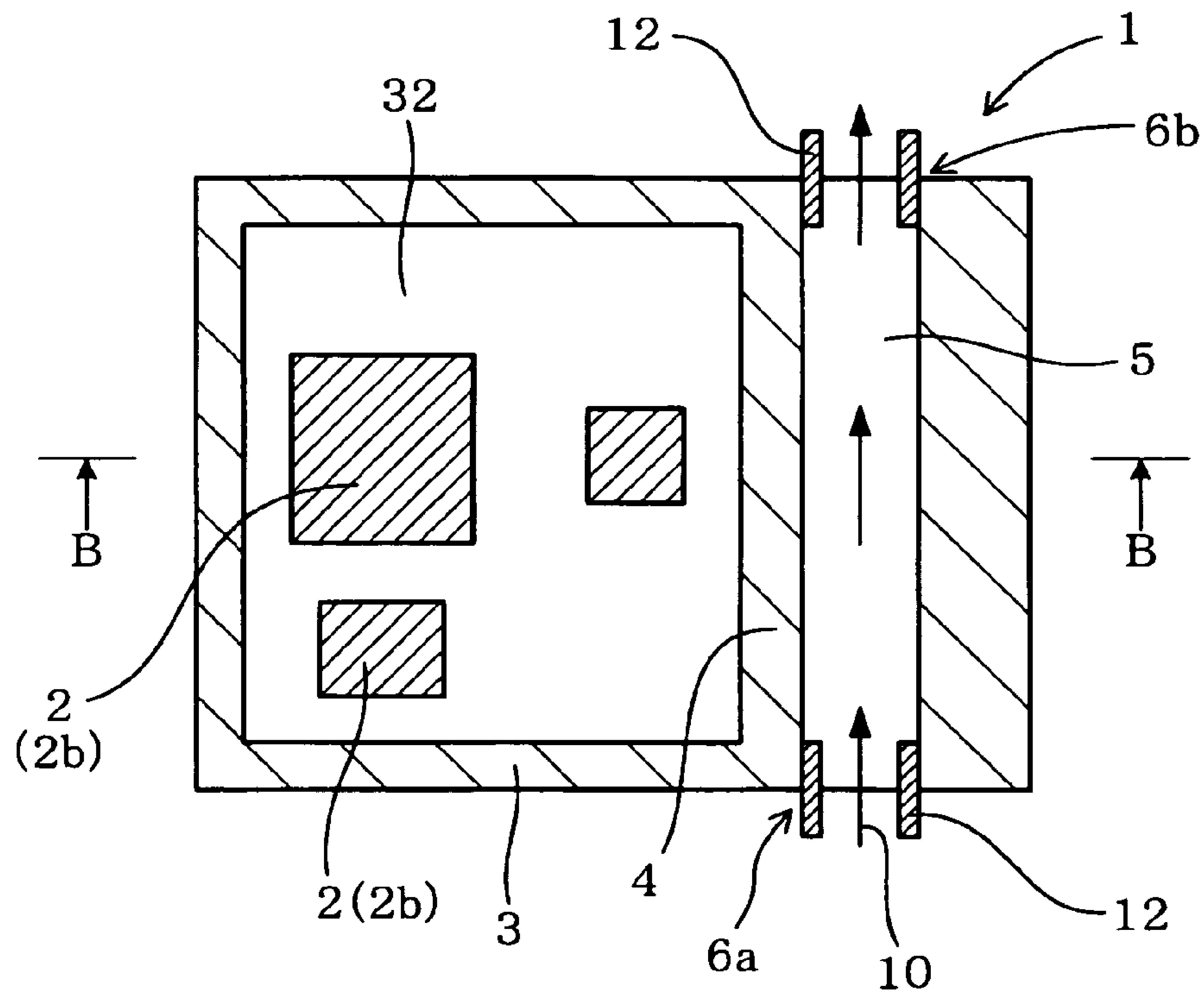


FIG.5

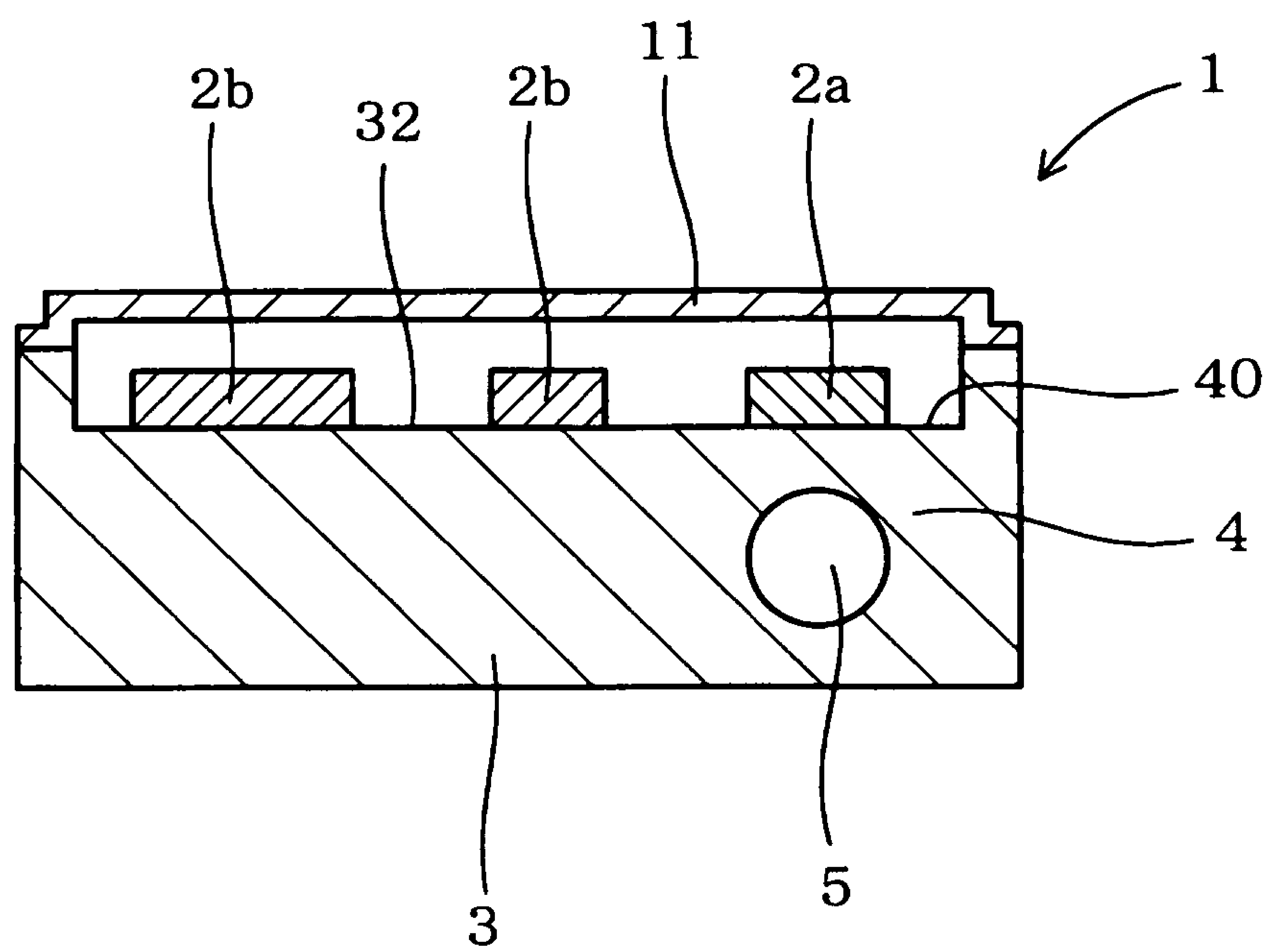


FIG.6

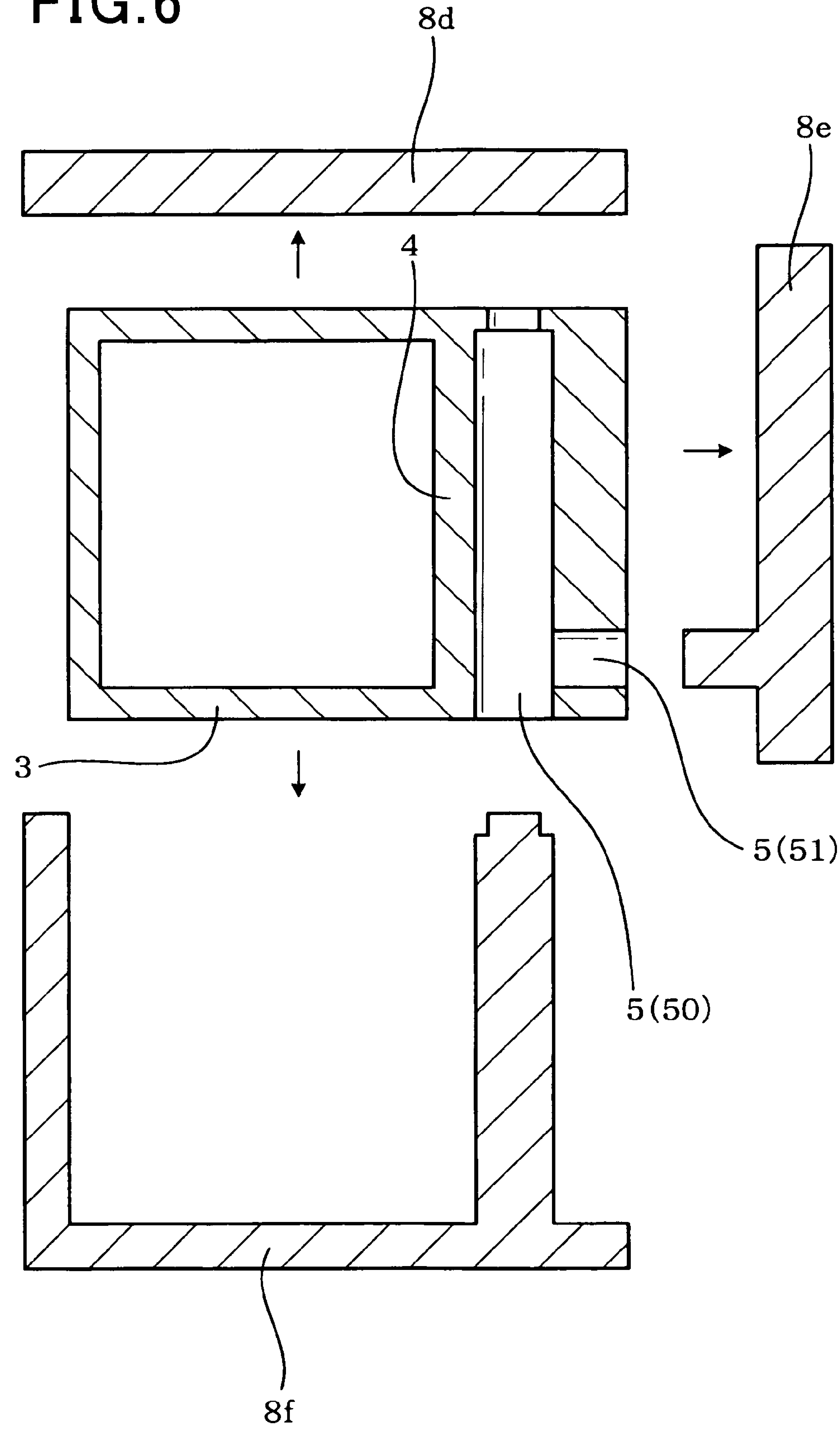


FIG.7

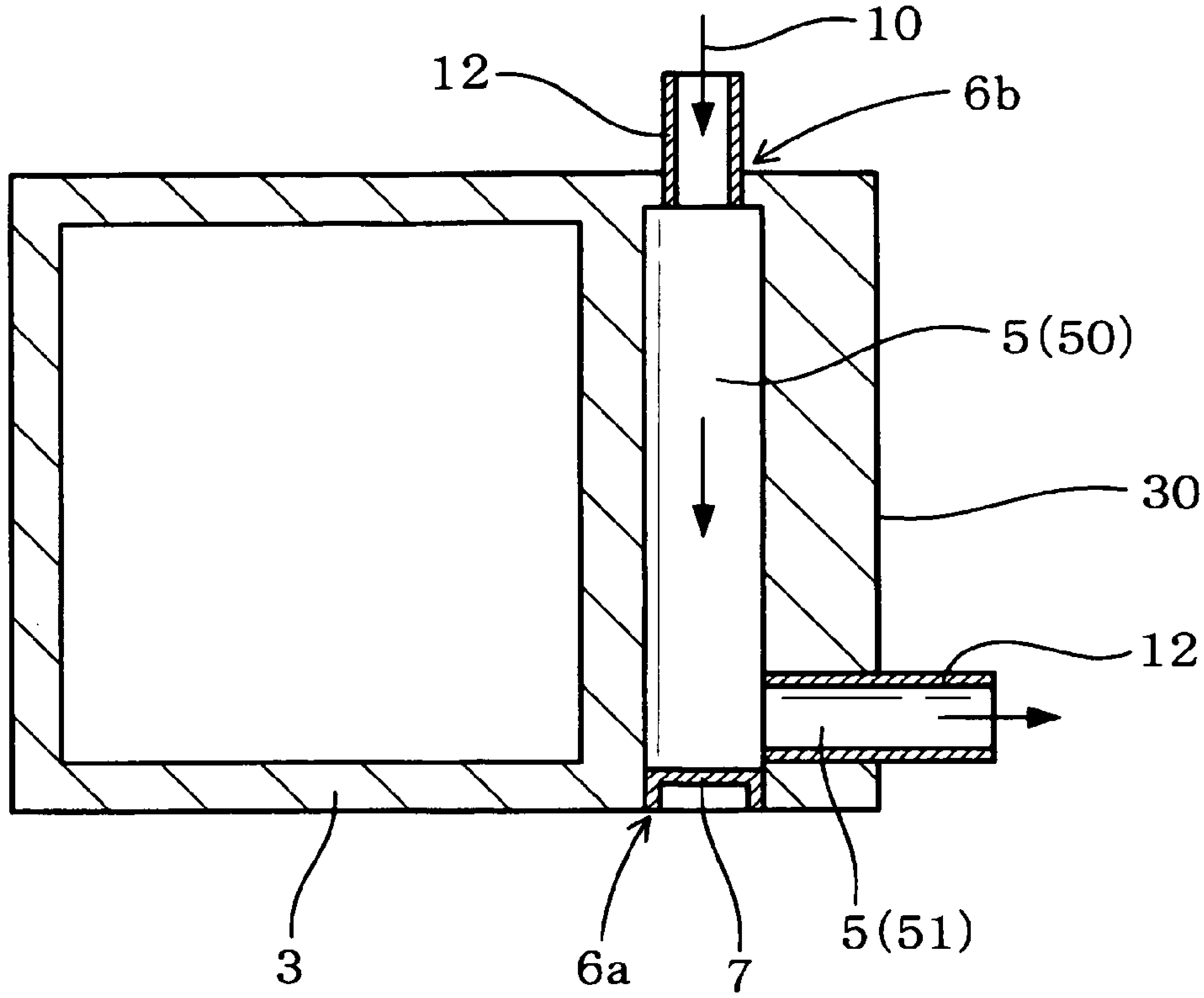


FIG.8

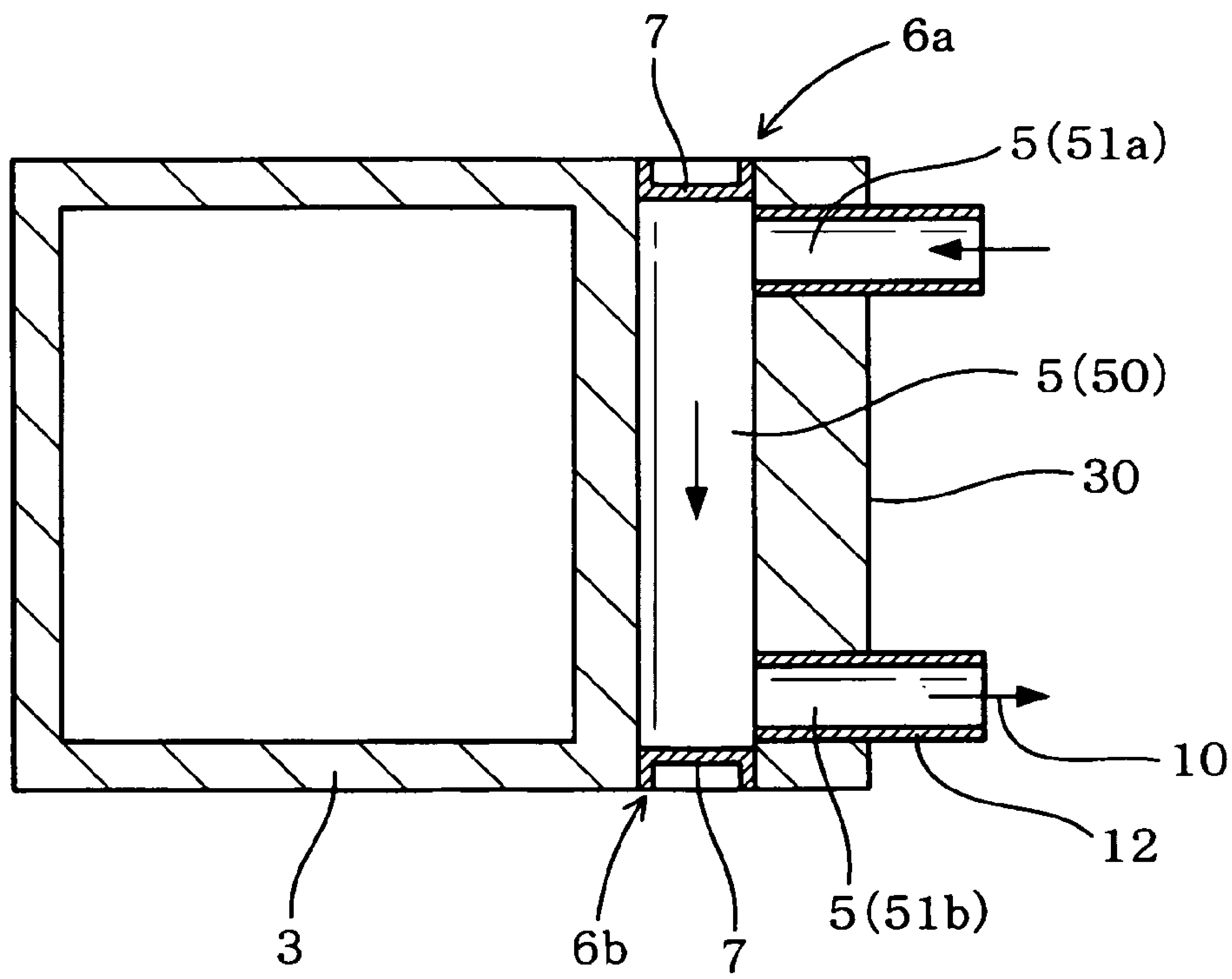


FIG.9

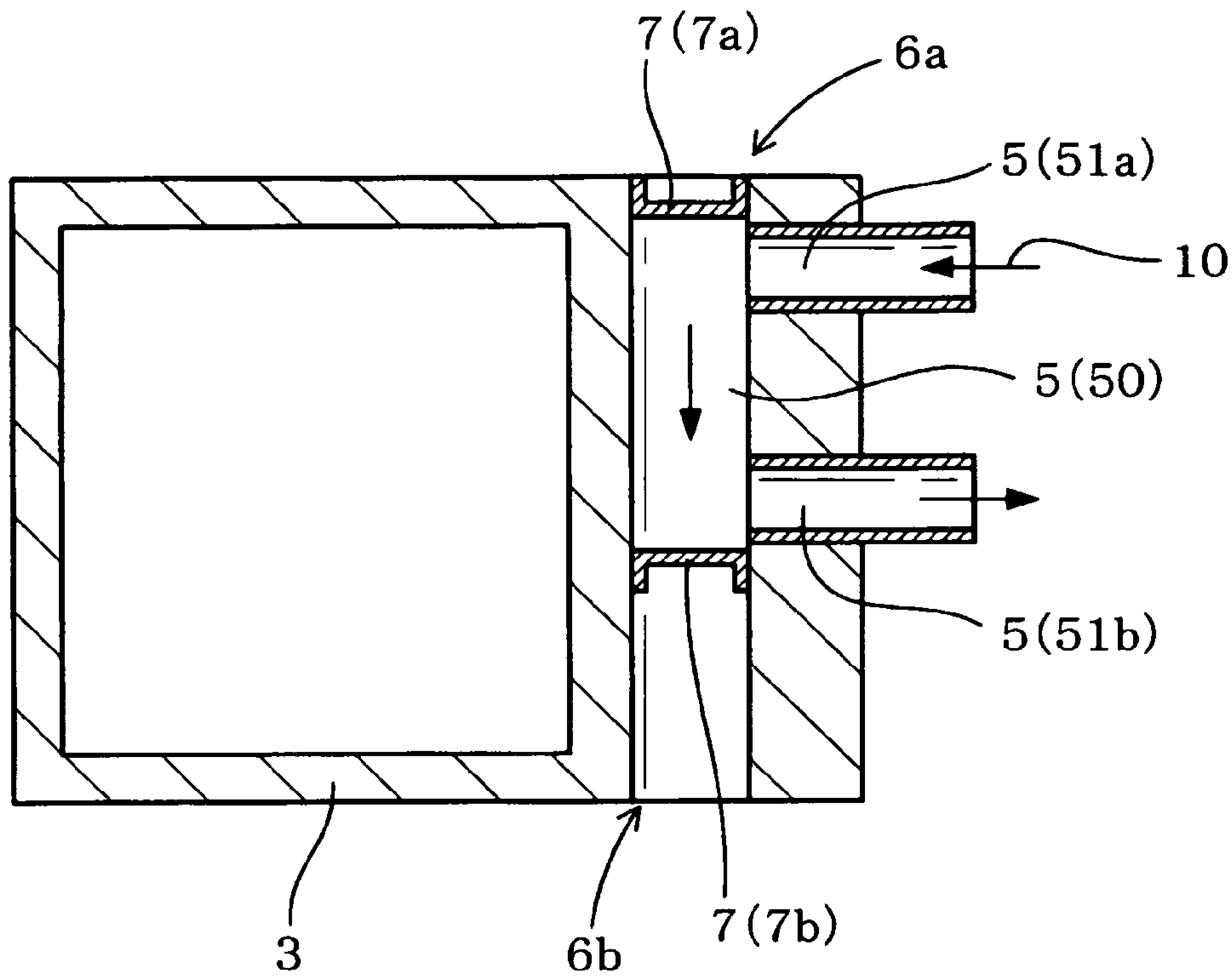
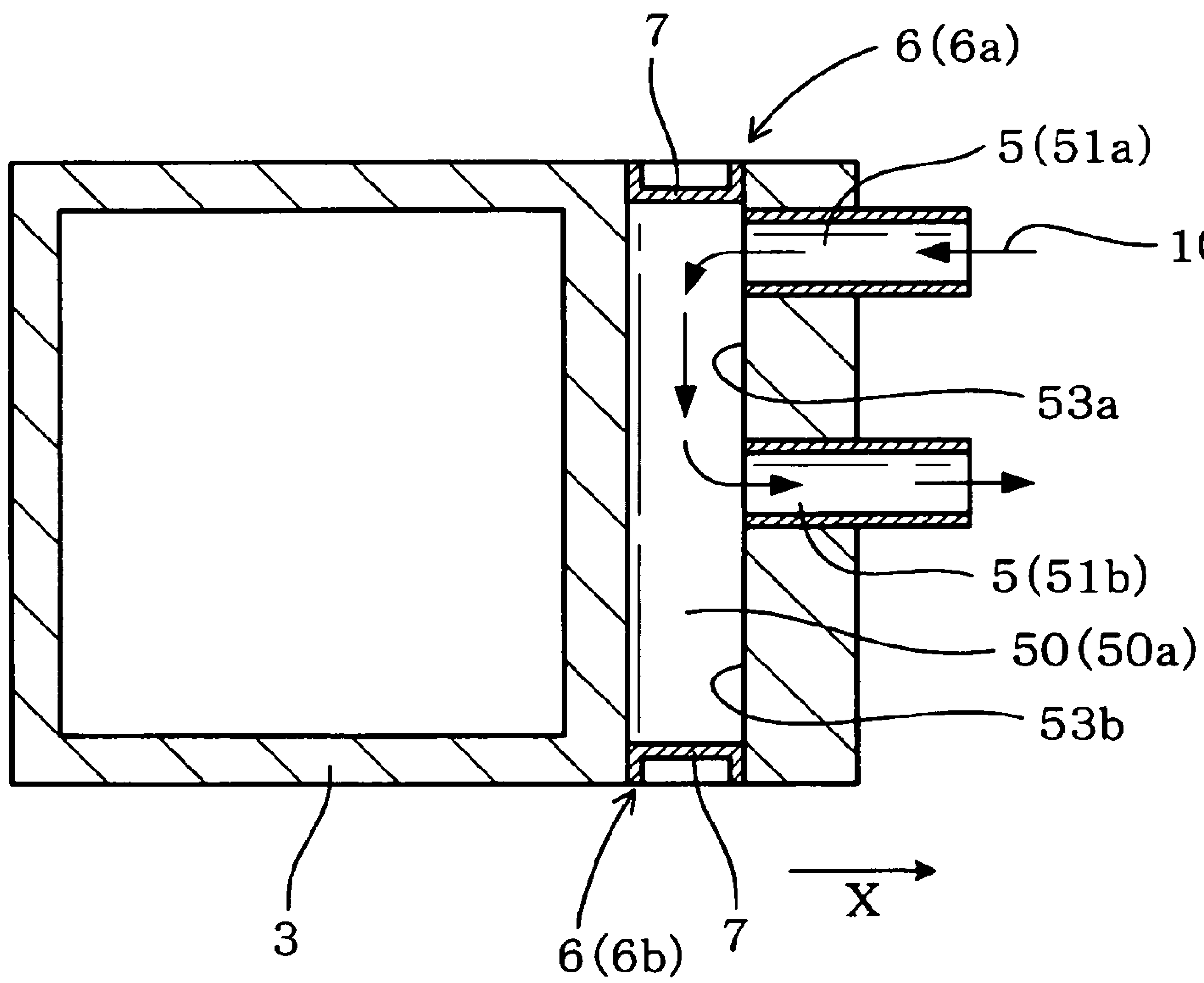

7(7a)
6a
5(51a)
10
5(50)
5(51b)
3
6b
7(7b)

FIG.10


7
6(6a)
5(51a)
10
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5(51b)
50(50a)
53b
3
6(6b)
7
X

FIG.11

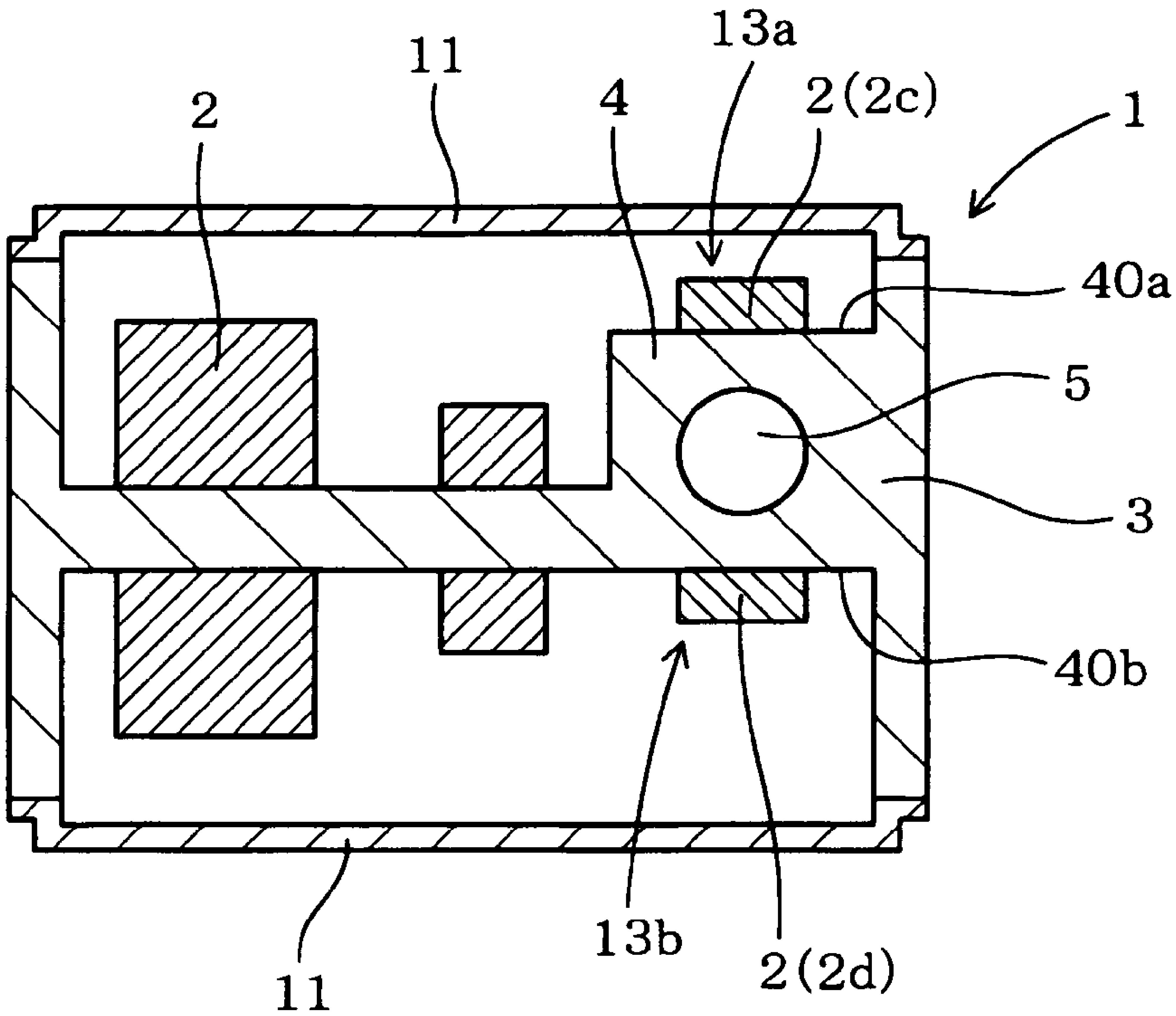


FIG.12

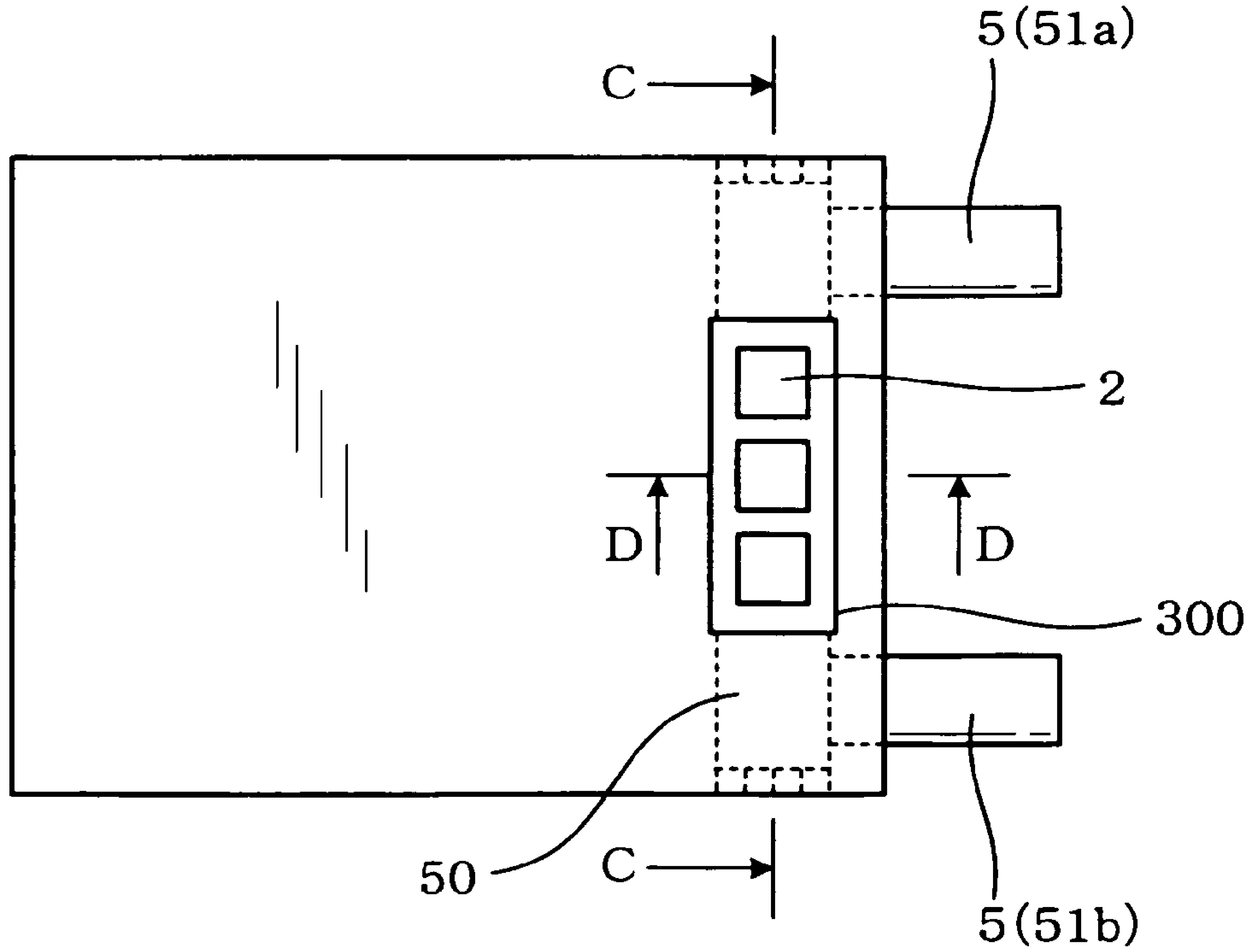


FIG. 13

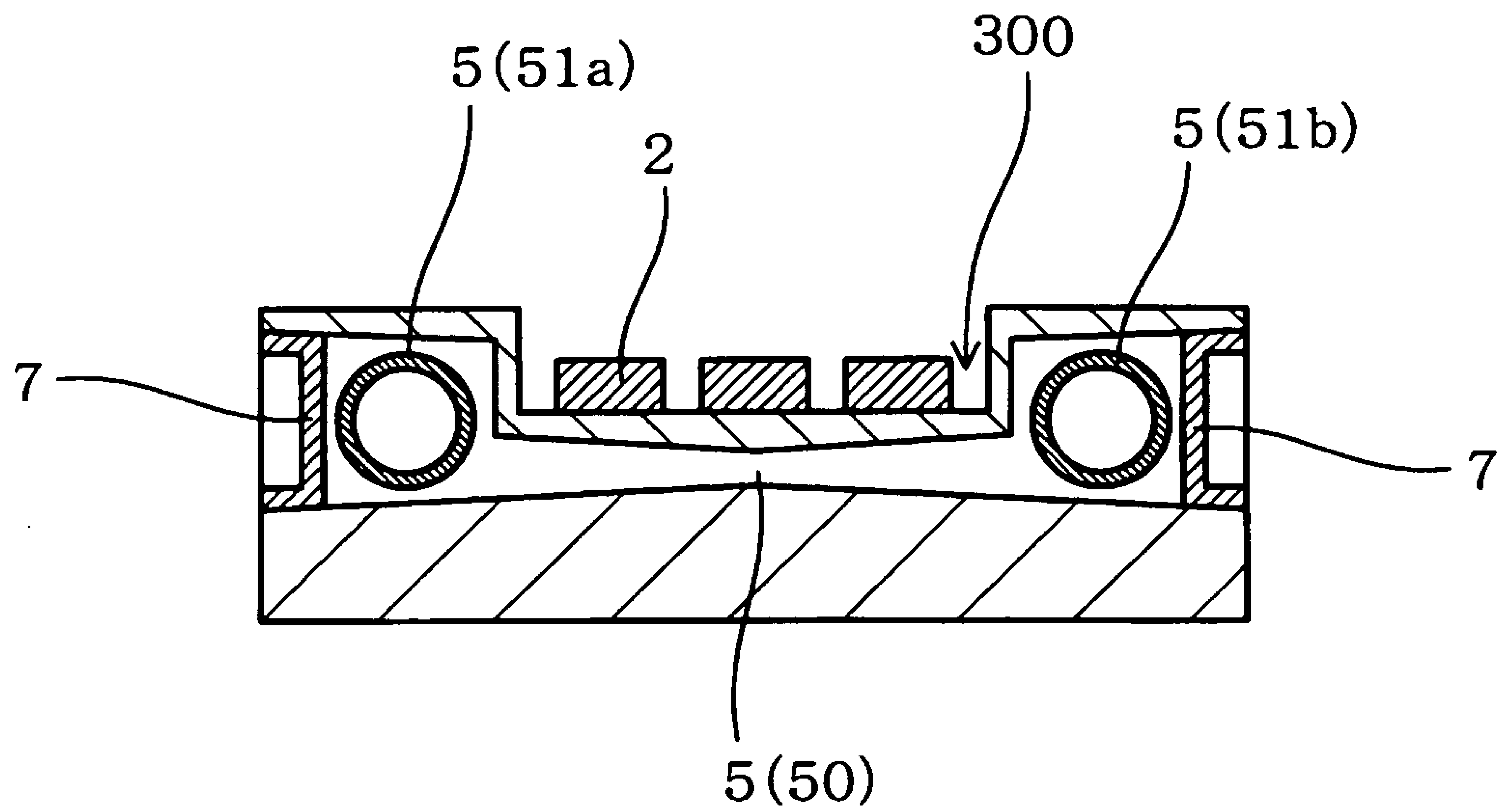


FIG. 14

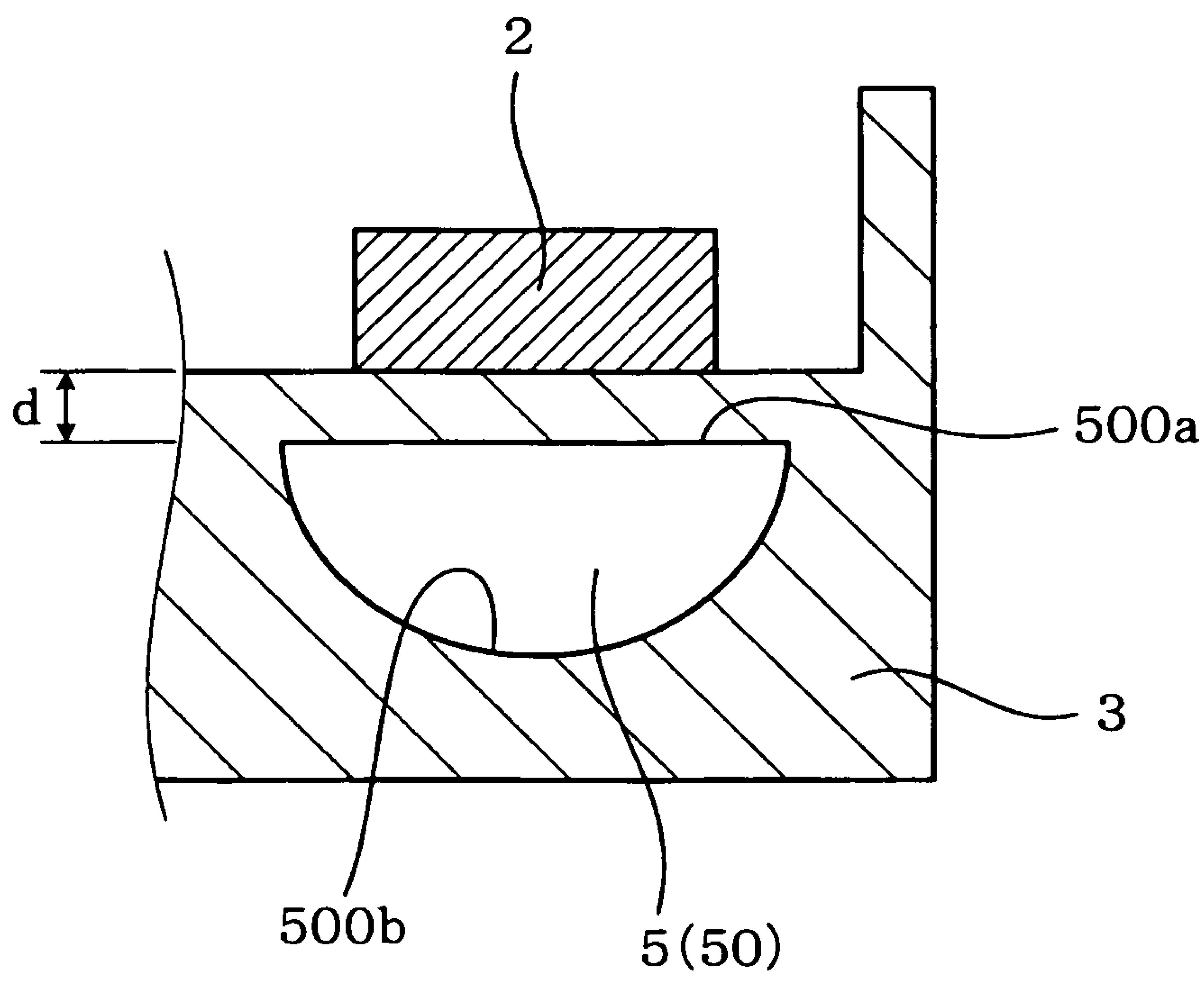
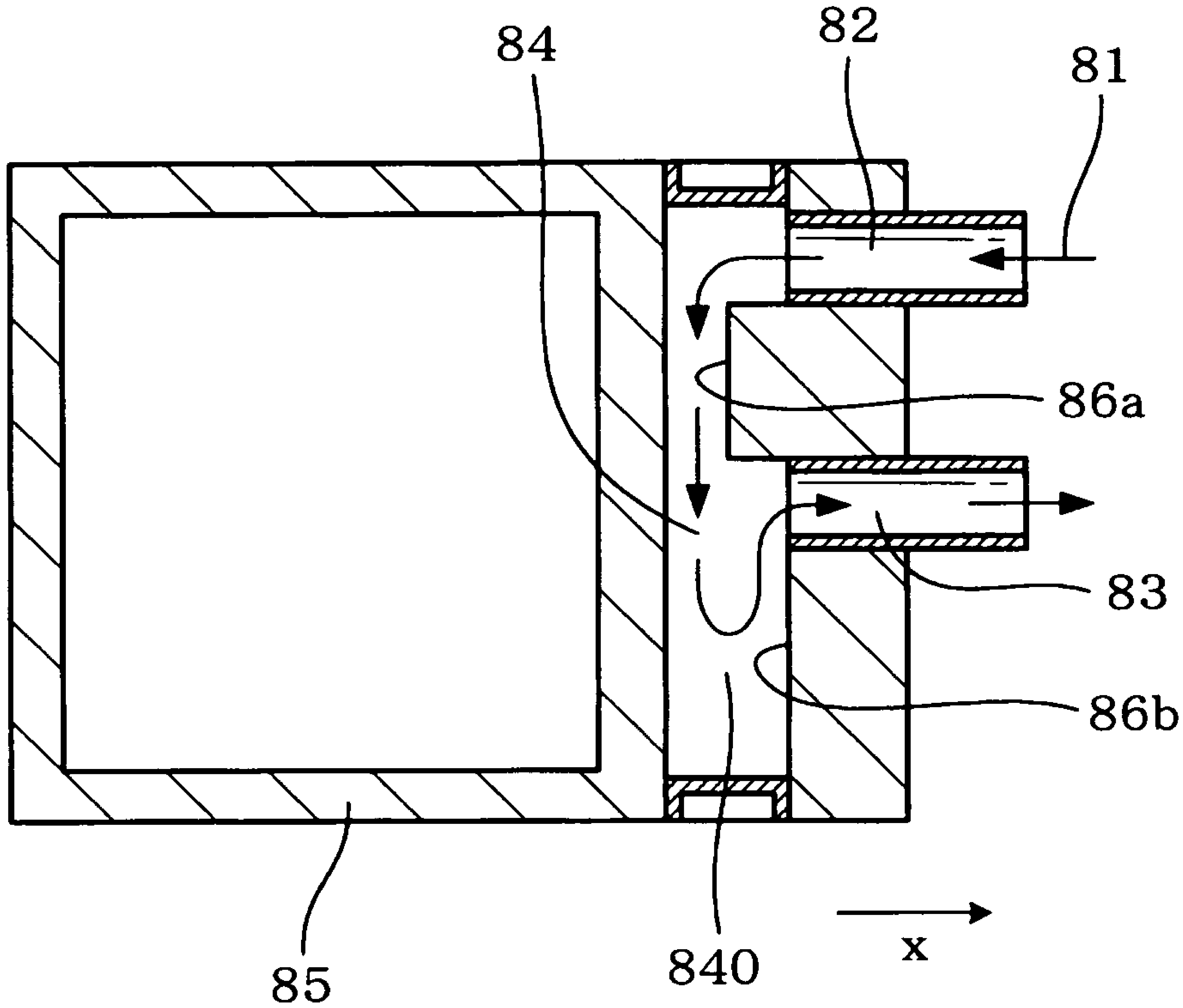


FIG. 15



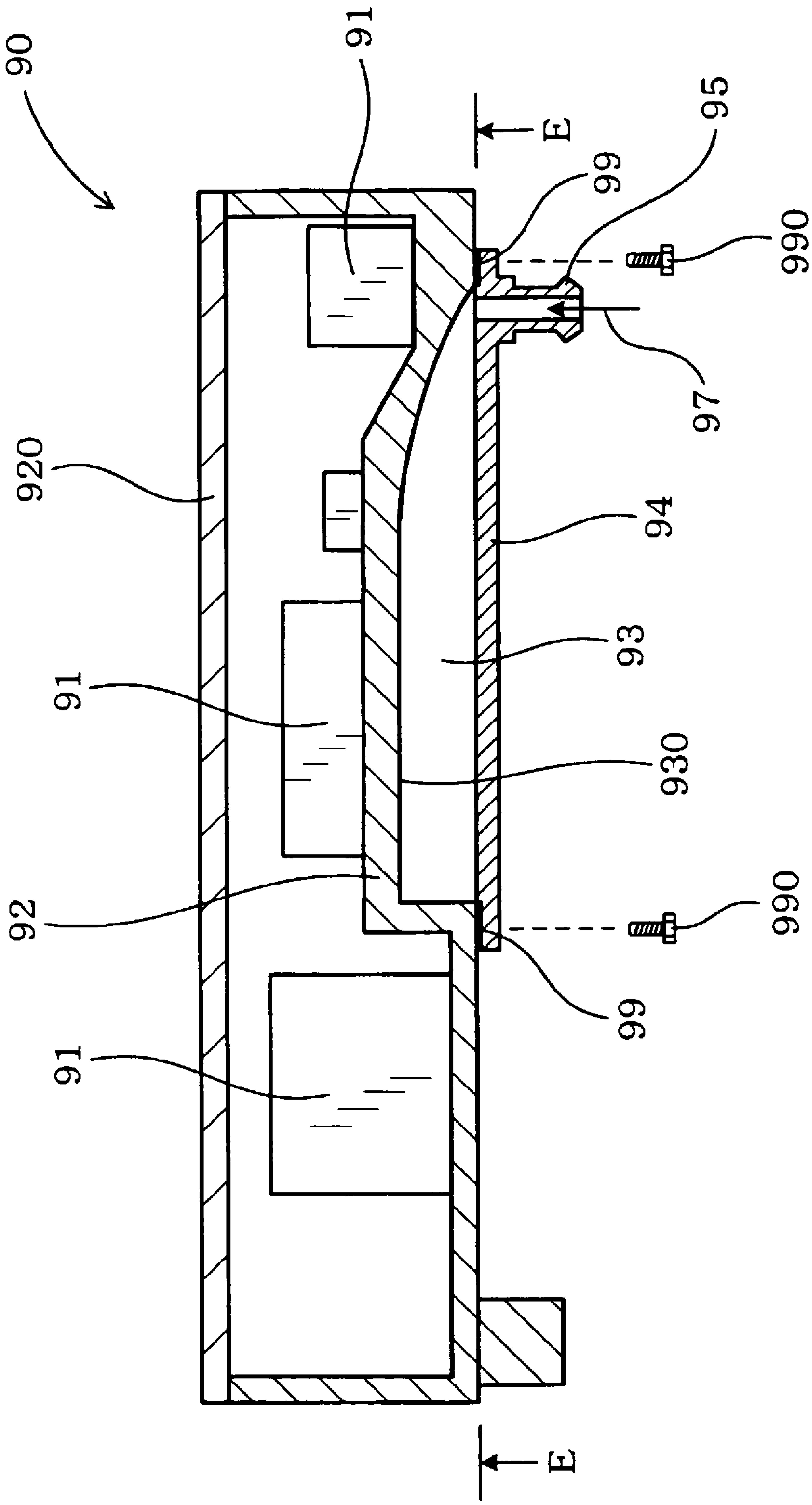


FIG. 16
PRIOR ART

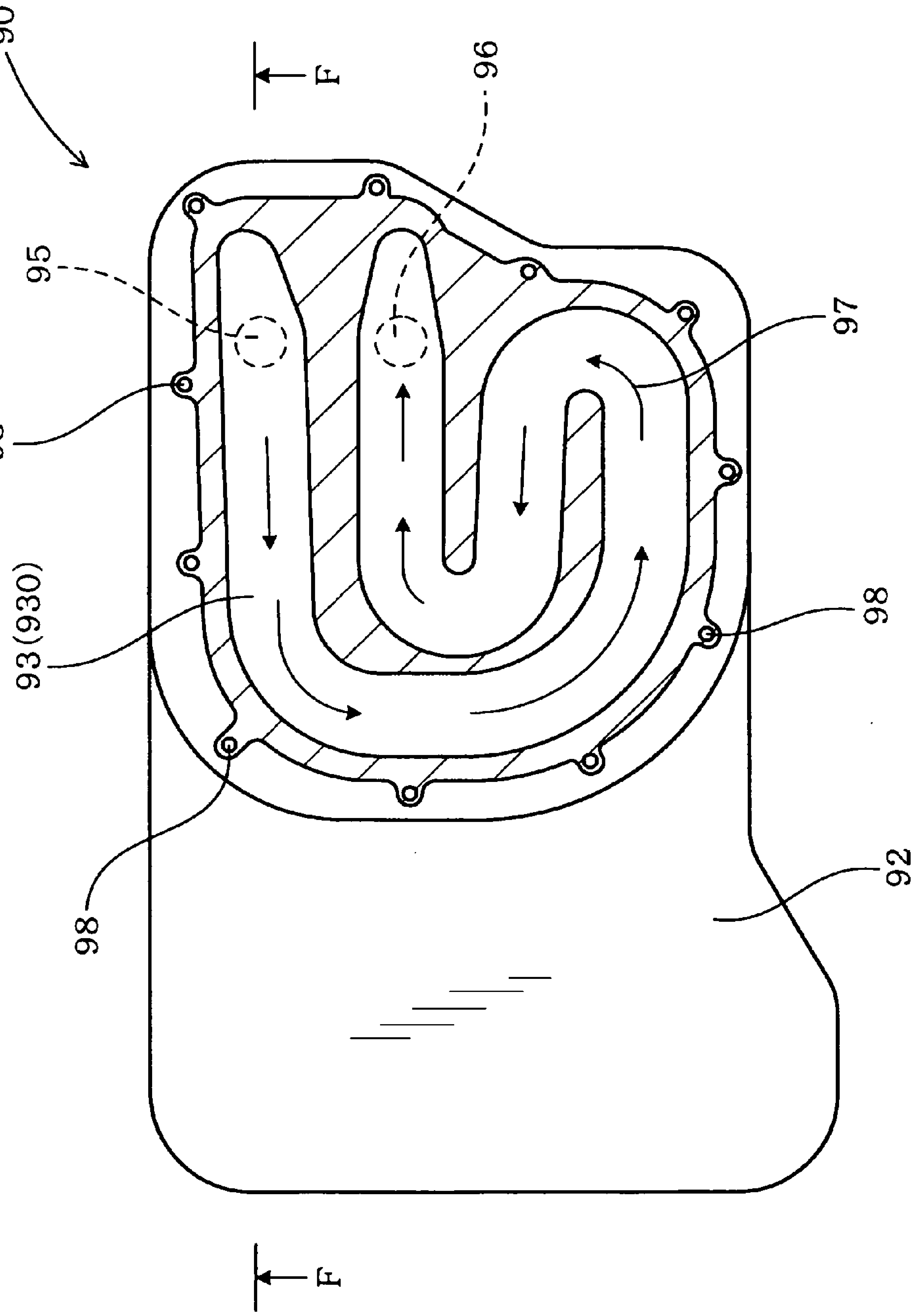


FIG. 17
PRIOR ART

SWITCHING POWER SUPPLY

CROSS-REFERENCE TO RELATED APPLICATION

This application is based on and claims the benefit of priority from earlier Japanese Patent Application No. 2010-101805 filed Apr. 27, 2010, the description of which is incorporated herein by reference.

BACKGROUND OF THE DISCLOSURE

1. Technical Field of the Disclosure

The present disclosure relates to a switching power supply provided with a casing for accommodating electronic parts.

2. Related Art

It is well known that a switching power supply that includes electronic parts has a casing for accommodating the electronic parts.

FIGS. **16** and **17** illustrate such a switching power supply **90** based on conventional art. The switching power supply **90** is provided with a casing **92** accommodating electronic parts **91**.

The casing **92** is provided with a coolant channel **93** through which a coolant **97** flows to cool the electronic parts **91**. For example, such a switching power supply is disclosed in JP-A-2004-297887.

In the interior of the casing **92** of the switching power supply **90**, the electronic parts **91** are mounted on the bottom surface. In the exterior of the casing **92**, a serpentine recess **930** that will serve as the coolant channel **93** is formed.

The casing **92** is provided with a channel cover **94** which is attached and fixed thereto by bolts **990** or the like. The recess **930**, together with the channel cover **94**, forms an enclosed serpentine space outside the casing **92**, which space serves as the coolant channel **93**.

Also, in order to prevent leakage of the coolant **97**, a sealing member **99** (see FIG. **16**) is interposed between the channel cover **94** and the casing **92**. The casing **92** is also provided with a protective cover **920** for protecting the electronic parts **91**.

The channel cover **94** is formed with an inlet **95** and an outlet **96** for the coolant **97**. The coolant **97** charged from the inlet **95** flows through the coolant channel **93** and discharged from the outlet **96**. Thus, the electronic parts **91** are cooled.

However, the switching power supply **90** based on the conventional art needs such parts as the channel cover **94**, the bolts **990** and the sealing member **99**, besides the casing **92**, to form the coolant channel **93**. Thus, the switching power supply **90** of the conventional art has suffered from a problem of needing a number of parts.

Also, in order to screw the bolts **990**, female thread portions **98** (see FIG. **17**) are required to be formed in the casing **92**. Therefore, there has been a problem that the size of the casing **92** is likely to be increased.

In addition, the switching power supply **90** of the conventional art requires a step of fastening the channel cover **94** to the casing **92** using the bolts **990** and a step of interposing the sealing member **99** between the channel cover **94** and the casing **92**. Thus, the switching power supply **90** of the conventional art has also suffered from a problem of increasing the number of steps.

SUMMARY OF THE DISCLOSURE

An embodiment provides a compact-size switching power supply which is manufactured with a reduced number of parts and a reduced number of steps.

In a switching power supply according to a first aspect, the switching power supply includes electronic parts that configure a switching circuit, a casing that accommodates the electronic parts, a seat member formed unitarily with the casing on which the electronic parts are mounted, and a coolant channel formed through the seat member so as to be open at least at two positions of an outer wall surface of the casing. Coolant that flows through the coolant channel cools the electronic parts mounted on the seat member.

In the switching power supply according to a second aspect, the coolant channel includes a primary channel formed through the seat member, and a secondary channel extended in a direction of intersecting the primary channel for connection thereto, and the connection is established at a position between end portions of the primary channel, with one end of the secondary channel being open in an outer wall surface of the casing.

One end portion of the end portions of the primary channel is provided with a stopper so that the coolant flows from the other end portion to the secondary channel through the primary channel.

In the switching power supply according to a third aspect, the coolant channel includes a primary channel formed through the seat member, and a pair of secondary channels extended in a direction of intersecting the primary channel for connection thereto, and the connection is established at a position between end portions of the primary channel, with one end of the secondary channel being open in an outer wall surface of the casing

Each of the end portions of the primary channel is provided with a stopper so that the coolant flows from one of the secondary channel to the other one of the secondary channel through the primary channel.

With this configuration, the degree of freedom of designing the switching power supply is enhanced.

Specifically, in the above configuration, one secondary channel may be used as an inlet of a coolant and the other secondary channel may be used as an outlet of the coolant. Since the secondary channels may be formed at optional positions between both ends of the primary channel, the positions of the inlet and the outlet of the coolant can be freely determined.

In the switching power supply according to a fourth aspect, the pair of secondary channels are extended in the same direction, the primary channel has a first side face on a side to which the pair of secondary channels are connected.

The first side face resides between the pair of secondary channels, and a second side face resides on an opposite side of the first side face with reference to the secondary channel on a downstream side.

The first side face coincides with the second side face regarding the position in a direction in which the secondary channels are extended.

With this configuration, pressure loss of the coolant is reduced. Specifically, let us assume that the first side face (see FIG. **15**) of the primary channel does not coincide with the second side face thereof regarding the position in a direction in which the secondary channel is projected.

In this case, eddies will be caused in the coolant in a region including the second side face, and thus there is a tendency that pressure loss of the coolant is increased. In this regard, the above configuration is likely to allow the coolant to stay in the region including the second side face.

Accordingly, the fresh coolant is inhibited from entering the region to thereby allow the coolant to smoothly flow from the primary channel toward the secondary channel on a downstream side. In this way, pressure loss of the coolant is reduced.

In the switching power supply according to a fifth aspect, a cross-sectional area of the secondary channel, which is perpendicular to a direction of flow of the coolant, is made smaller than that of the primary channel.

A larger cross-sectional area of the primary channel will cause smaller pressure loss when the coolant flows, and also will achieve higher cooling efficiency. Meanwhile, a larger cross-sectional area of the secondary channels will also cause smaller pressure loss in the coolant.

However, if electronic parts are mounted above the primary channel, the larger cross-sectional area of each of the secondary channels will not so much contribute to raising the efficiency of cooling the electronic parts.

In addition, if the cross-sectional area of each secondary channel is made larger, a pipe or the like to be connected to the secondary channel is required to have a larger diameter accordingly, departing from the advantages such as of using a general-purpose pipe.

In this regard, with the above configuration of the present disclosure, each secondary channel may have a diameter in conformity with a general-purpose pipe or the like to be connected thereto, while the primary channel may have a larger cross-sectional area. In this way, pressure loss of the coolant is reduced and the efficiency of cooling the electronic parts is enhanced.

In the switching power supply according to a sixth aspect, the seat member has major surfaces on both sides thereof with an interposition of the coolant channel, different electronic parts are mounted on the major surfaces, and the electronic part mounted on one of the major surface of the seat member configures a switching circuit, while the electronic part mounted on the other one of the major surface of the seat member configures another switching circuit.

With the above configuration, two switching circuits are configured in a single casing.

Also, the electronic parts configuring the individual switching circuits are cooled using a single coolant channel. Thus, the number of casings and the number of coolant channels can both be reduced, whereby the switching power supply is manufactured at lower cost.

Further, since no stopper of the coolant channel is provided on the surface where the electronic parts are mounted, the coolant is prevented from flowing onto the surface of mounting the electronic parts.

Otherwise, the coolant would flow onto the surface of mounting the electronic parts in the event the coolant has leaked from a sealing portion between the stopper and the casing. Thus, the coolant will flow out of the switching power supply in the event of such leakage without flowing onto the surface of mounting the electronic parts.

Therefore, breakage or the like of the electronic parts would not be caused in the switching power supply.

In the switching power supply according to a seventh aspect, the switching power supply further includes a protective cover that covers the casing, and a weakly cooled area formed unitarily with the casing for mounting the electronic parts.

The amount of heat generated by the electronic parts mounted on the seat member is larger that of the electronic parts mounted on the weakly cooled area, and a distance from the seat member to the protective cover is shorter than a distance from the weakly cooled area to the protective cover.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** is a perspective view illustrating a switching power supply according to a first embodiment of the present disclosure;

FIG. **2** is a perspective view illustrating a method of manufacturing a casing according to the first embodiment;

FIG. **3** is a vertical cross-sectional view illustrating the switching power supply taken along a B-B line of FIG. **4** according to the first embodiment;

FIG. **4** is a horizontal cross-sectional view taken along an A-A line of FIG. **3**;

FIG. **5** is a vertical cross-sectional view illustrating the switching power supply according to the first embodiment, in which the level of a weakly cooled area is brought to the same level as that of the top surface of a seat member;

FIG. **6** is an explanatory view illustrating a method of manufacturing a casing according to a second embodiment of the present disclosure;

FIG. **7** is a horizontal cross-sectional view illustrating the casing of a switching power supply according to the second embodiment;

FIG. **8** horizontal is a cross-sectional view illustrating a casing of a switching power supply according to a third embodiment of the present disclosure;

FIG. **9** is a horizontal cross-sectional view illustrating a casing of a switching power supply according to a fourth embodiment of the present disclosure;

FIG. **10** horizontal is a cross-sectional view illustrating a casing of a switching power supply according to a fifth embodiment of the present disclosure;

FIG. **11** is a vertical cross-sectional view illustrating a casing of a switching power supply according to a sixth embodiment of the present disclosure;

FIG. **12** is a plan view illustrating a switching power supply according to a seventh embodiment of the present disclosure;

FIG. **13** is a vertical cross-sectional view taken along a C-C line of FIG. **12**;

FIG. **14** is a vertical cross-sectional view taken along a D-D line of FIG. **12**;

FIG. **15** is a horizontal cross-sectional view illustrating a casing of a switching power supply according to a comparative example;

FIG. **16** is vertical a cross-sectional view illustrating a switching power supply according to conventional art taken along an F-F line of FIG. **17**; and

FIG. **17** is a horizontal cross-sectional view taken along an E-E line of FIG. **16**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the accompanying drawings, hereinafter will be described several embodiments of the present disclosure.

(First Embodiment)

Referring to FIGS. **1** to **5**, hereinafter is described a switching power supply according to a first embodiment of the present disclosure. FIG. **1** is a perspective view illustrating a switching power supply **1** according to the first embodiment.

As shown in FIG. **1**, the switching power supply **1** of the present embodiment includes a switching circuit **13**, electronic parts **2** configuring the switching circuit **13**, a seat member **4** on which the electronic parts **2** are mounted and a coolant channel **5** through which a coolant **10** flows.

The electronic parts **2** are accommodated in a casing **3**. The seat member **4** is integrally formed with the casing **3**. The coolant channel **5** is formed through the seat member **4** so as to be open at least at two positions of an outer wall surface **30** of the casing **3**.

The coolant **10** that flows through the coolant channel **5** cools the electronic parts **2** mounted on the seat member **4**.

Specific description is set forth below.

As shown in FIG. **1**, the coolant channel **5** has end portions **6** at both ends thereof, each of which is connected to a pipe **12**. Piping, such as a hose (not shown), is attached to the pipes **12** to flow the coolant **10** through the coolant channel **5** of the switching power supply **1**.

The casing **3** accommodates a plurality of electronic parts **2**. Of the electronic parts **2**, those electronic parts **2***a* which easily generate heat are mounted on the seat member **4**, however, those electronic parts **2***b* which generate small amount of heat are not mounted on the seat member **4**.

FIG. **2** is a perspective view illustrating a method of manufacturing the casing **3** of the first embodiment. As shown in FIG. **2**, the casing **3** and the seat member **4** are integrally formed by casting.

Specifically, a plurality of casting mold parts **8***a* to **8***c* are assembled to provide a casting mold **8** into which molten metal is cast. Then, the molten metal is cooled and solidified, followed by withdrawing the casting mold parts **8***a* to **8***c* in the arrowed directions indicated in FIG. **2** to take out the casing **3**.

The casting mold part **8***a* has a projection **81** corresponding to an accommodating space **31** of the casing **3**. The casing molds **8***b* and **8***c* have columnar portions **82** and **83**, respectively.

When the casting mold parts **8***b* and **8***c* are assembled, the columnar portions **82** and **83** are joined and the joined portions form a portion corresponding to the coolant channel **5**.

It should be appreciated that the columnar portions **82** and **83** may be integrated into a single columnar portion to provide a casting mold part having a single columnar portion. Alternatively, instead of the columnar shape, the portions **82** and **83** may have a different shape in conformity with the shape of electronic parts to be mounted.

FIG. **3** is a vertical cross-sectional view illustrating the switching power supply **1** of the first embodiment taken along a B-B line of FIG. **4**. FIG. **4** is a horizontal cross-sectional view taken along an A-A line of FIG. **3**.

After integrally molding the casing **3** and the seat member **4**, the pipes **12** are attached, as shown in FIG. **4**, to the respective end portions **6** of the coolant channel **5**.

Further, as shown in FIG. **3**, the electronic parts **2** are accommodated in the casing **3**, and a protective cover **11** is attached to the casing **3** to protect the electronic parts **2**.

As shown in FIGS. **3** and **4**, the casing **3** has a weakly cooled area **32** for mounting the electronic parts **2***b* that generate less heat. Meanwhile, the seat member **4** has a mounting surface **40** for mounting the electronic parts **2***a* that easily generate heat, or generate large amount of heat.

The height from the weakly cooled area **32** to the protective cover **11** is h**2** which is larger than h**1** that is the height from the mounting surface **40** to the protective cover **11**. In this way, the electronic parts **2***b*, if they have a large size, are ensured to be mounted in the weakly cooled area **32**.

The electronic parts **2***a* that generate large amount of heat include, for example, semiconductor modules incorporating switching elements. The electronic parts **2***b* that generate small amount of heat include, for example, capacitors or reactors.

FIG. **5** is a vertical cross-sectional view illustrating the switching power supply **1** of the first embodiment, in which the level of the weakly cooled area **32** is brought to the same level as that of the mounting surface **40** of seat member **4**.

As shown in FIG. **5**, if the height of the electronic part **2***b* mounted on the weakly cooled area **32** is not so large, the weakly cooled area **32** may be permitted to reside in the plane extended from the mounting surface **40** of the seat member **4**.

Hereinafter are described advantages and effects of the present embodiment.

In the present embodiment, the seat member **4** for mounting the electronic parts **2** is integrated with the casing **3**, with the coolant channel **5** being formed through the seat member **4**. Thus, in forming the coolant channel **5**, the number of parts can be reduced, and at the same time, the size of the casing **3** can be reduced.

Specifically, for example, let us compare the present embodiment with the case, as shown in FIG. **16**, where the casing **92** is assembled with the channel cover **94** to form the coolant channel **93**.

As will be understood from the comparison, the present embodiment dispenses with the channel cover **94**, the bolts **990**, and the like, and thus the number of parts can be reduced.

The present embodiment also dispenses with the female thread portions **98** for screwing the bolts **990** (see FIG. **16**), whereby the size of the casing **3** can be reduced.

Further, the coolant channel **5** is formed through the seat member **4** which is integrated into the casing **3**. Therefore, assemblage of a separately provided member is not necessary in forming the coolant channel **5**. In other words, the step such as of connecting the channel cover **94** (see FIG. **16**) to the casing **92**, for example, can be omitted. Thus, the number of steps for manufacturing the switching power supply **1** is reduced.

As mentioned above, the electronic parts **2***a* that generate a large amount of heat include, for example, semiconductor modules whose height is small in general.

Therefore, when such semiconductor modules are arranged on the seat member **4** in which the coolant channel **5** is formed, adjustment to approximately the same height as the height h**2** is possible. In this way, the dead space in the switching power supply is reduced to thereby reduce the size of the switching power supply.

As described above, in the switching power supply **1** according to the present embodiment, the size, the number of parts, and the number of steps are all reduced.

(Second Embodiment)

Referring to FIGS. **6** and **7**, hereinafter is described a second embodiment of the present disclosure. FIG. **6** is an explanatory view illustrating a method of manufacturing the casing **3** according to the second embodiment. FIG. **7** is a horizontal cross-sectional view illustrating the casing **3** of the switching power supply **1** according to the second embodiment.

It should be appreciated that, in the second and the subsequent embodiments, the components identical with or similar to those in the first embodiment are given the same reference numerals for the sake of omitting explanation.

The second embodiment is different from the first embodiment in that the shape of the coolant channel **5** has been changed.

As shown in FIG. **7**, the coolant channel **5** of the present embodiment includes a primary channel **50** and a secondary channel **51**. The primary channel **50** is formed through the seat member **4**. The secondary channel **51** is extended in the direction of intersecting the primary channel **50** for connection thereto.

The connection is established at a position between the end portions **6***a* and **6***b* of the primary channel **50**, with one end of the secondary channel **51** being open in the outer wall surface **30** of the casing **3**. Of the end portions **6***a* and **6***b* of the primary channel **50**, the end portion **6***a* is provided with a stopper **7** so that the coolant **10** will flow, for example, from the end portion **6***b* to the secondary channel **51** through the primary channel **50**.

In the present embodiment as well, the casing **3** is integrally formed with the seat member **4** by casting. Specifically, as sown in FIG. **6**, a plurality of casting mold parts **8***d* to **8***f* are assembled to form the casting mold **8**, followed by casting molten metal in the casting mold **8**.

Then, the cast molten metal is cooled for solidification, followed by withdrawing the casting mold parts **8***d* to **8***f* in the arrowed directions indicated in FIG. **6**.

It should be appreciated that the cross-sectional area of the secondary channel **51**, which is perpendicular to the direction of flow of the coolant **10**, is made smaller than that of the primary channel **50**.

The remaining configuration is similar to the first embodiment.

The advantages and effects of the second embodiment will be described below.

The configuration of the second embodiment contributes to enhancing the degree of freedom of designing the switching power supply **1**. Specifically, when the primary channel **50** alone is provided, the end portion **6***a* of the primary channel **50** necessarily has to be an inlet of the coolant, while the end portion **6***b* necessarily has to be an outlet of the coolant.

Thus, the positions of the inlet and the outlet cannot be freely changed. However, as shown in FIG. **7**, with the configuration of the present embodiment, the secondary channel **51** is formed at an optional position between the end portions **6***a* and **6***b* of the primary channel **50**. Accordingly, the position of at least one of the inlet and the outlet of the coolant is freely determined.

Also, with the above configuration of the present embodiment, the secondary channel may have a diameter in conformity with a general-purpose pipe or the like to be connected thereto, while the primary channel may have a larger cross-sectional area. In this way, pressure loss of the coolant is reduced and the efficiency of cooling the electronic parts is enhanced.

Other advantages and effects are similar to those of the first embodiment.

(Third Embodiment)

Referring to FIG. **8**, a third embodiment of the present disclosure is described. FIG. **8** is a horizontal cross-sectional view illustrating the casing **3** of the switching power supply **1** according to the third embodiment.

As shown in FIG. **8**, the coolant channel **5** of the third embodiment includes the primary channel **50** and a pair of secondary channels **51***a* and **5***ab*. The primary channel **50** is formed through the seat member **4**.

The pair of secondary channels **51***a* and **51***b* is extended in the direction of intersecting the primary channel **50** for connection thereto. The connections are established at the positions between the end portions **6***a* and **6***b* of the primary channel **50**.

The secondary channels **51***a* and **51***b* each have an end which is open in the outer wall surface **30** of the casing **3**. Each of the end portions **6***a* and **6***b* of the primary channel **50** is provided with the stopper **7** so that the coolant **10** will flow, for example, from the secondary channel **51***a* to the secondary channel **51***b* through the primary channel **50**.

The remaining configuration is similar to the first embodiment.

The advantages and effects of the third embodiment are described.

The configuration of the third embodiment contributes to further enhancing the degree of freedom of designing the switching power supply **1**.

Specifically, in the configuration of the third embodiment, the secondary channel **51***a* may be used as an inlet of the coolant, for example, while the secondary channel **51***b* may be used as an outlet of the coolant.

Since the secondary channels **51***a* and **51***b* are formed at optional positions between the end portions **6***a* and **6***b* of the primary channel **50**, the positions of the inlet and the outlet of the coolant can be freely determined.

Other advantages and effects are similar to those of the first embodiment.

(Fourth Embodiment)

Referring to FIG. **9**, hereinafter is described a fourth embodiment of the present disclosure. FIG. **9** is a horizontal cross-sectional view illustrating the casing **3** of the switching power supply **1** according to the fourth embodiment.

As shown in FIG. **9**, the coolant channel **5** of the fourth embodiment includes the primary channel **50** and a pair of secondary channels **51***a* and **51***b*. A stopper **7***a* is attached to the end portion **6***a* of the primary channel **50**.

Another stopper **7***b* is provided in the primary channel **50** so as to be positioned nearer the end portion **6***a* with reference to the end portion **6***b*. The pair of secondary channels **51***a* and **51***b* is connected to the primary channel **50**. The connection is established at positions between the stoppers **7***a* and **7***b*.

The remaining configuration is similar to the first embodiment.

The advantages and effects of the fourth embodiment are described.

The configuration of the present embodiment is effective in the case where the electronic parts **2** are mounted only in an area corresponding to the area that falls between the stoppers **7***a* and **7***b*. In the present embodiment, since one of the stoppers is provided at a position near the secondary channel **51***b*, the volume of the coolant in the channel is reduced.

Other advantages and effects are similar to those of the first embodiment.

(Fifth Embodiment)

Referring to FIG. **10**, a fifth embodiment of the present disclosure is described. FIG. **10** is a horizontal cross-sectional view illustrating the casing **3** of the switching power supply **1** according to the fifth embodiment.

In the fifth embodiment, the shape of the coolant channel **5** has been changed. As shown in FIG. **10**, the pair of secondary channels **51***a* and **51***b* of the present embodiment are extended in the same direction.

The primary channel **50** has a first side face **53***a* on the side to which the pair of secondary channels **51***a* and **51***b* are connected, the first side face **53***a* residing between the pair of secondary channels **51***a* and **51***b*.

The primary channel **50** also has a second side face **53***b* residing on the opposite side of the first side face **53***a* with reference to the secondary channel **51***b* on a downstream side.

The first side face **53***a* coincides with the second side face **53***b* regarding the position in a direction X in which the secondary channels **51***a* and **51***b* are extended.

The remaining configuration is similar to the first embodiment.

The advantages and effects of the fifth embodiment are described.

The configuration of the fifth embodiment contributes to reducing pressure loss of the coolant **10**.

FIG. **15** is a horizontal cross-sectional view of a casing of a switching power supply according to a comparative example.

As shown in FIG. **15**, let us assume that a first side face **86***a* of a primary channel **84** does not coincide with a second side face **86***b* thereof regarding the position in a direction x in which secondary channels **82** and **83** are projected. In this case, eddies will be caused in a coolant **81** in a region **840** in the primary channel **84**, the region **840** including the second side face **86***a*, and thus there is a tendency that pressure loss of the coolant **81** is increased.

In this regard, as shown in FIG. **10**, the configuration of the present embodiment is likely to allow the coolant **10** to stay in a region **50***a* in the primary channel **50**, the region **50***a* including the second side face **53***b*.

Accordingly, the coolant **10** is unlikely to newly enter the region **50***a* to thereby allow the coolant **10** to smoothly flow from the primary channel **50** toward the secondary channel **51***b* on a downstream side. In this way, pressure loss of the coolant **10** is reduced.

Other advantages and effects are similar to those of the first embodiment.

(Sixth Embodiment)

Referring to FIG. **11**, a sixth embodiment of the present disclosure is described. FIG. **11** is a vertical cross-sectional view illustrating the casing **3** of the switching power supply **1** according to the sixth embodiment.

In the sixth embodiment, the shape of the casing **3** has been changed. As shown in FIG. **11**, the seat member **4** has major surfaces **40***a* and **40***b* on both sides thereof with an interposition of the coolant channel **5**. Different electronic parts **2***c* and **2***d* are mounted on the major surfaces **40***a* and **40***b*, respectively.

The electronic part **2***c* mounted on the major surface **40***a* of the seat member **4** configures a switching circuit **13***a*. Meanwhile, the electronic part **2***d* mounted on the major surface **40***b* of the seat member **4** configures another switching circuit **13***b*.

The remaining configuration is similar to the first embodiment.

The advantages and effects of the sixth embodiment are described.

With the configuration of the sixth embodiment, the two switching circuits **13***a* and **13***b* are configured within a single casing **3**. Further, the electronic parts **2***c* and **2***d* configuring the switching circuits **13***a* and **13***b*, respectively, are cooled by a single coolant channel **5**.

Thus, the number of the casings **3** and the number of the coolant channels **5** are both reduced. As a result, the number of parts of the switching power supply **1** is reduced to thereby realize the switching power supply **1** with a compact size.

Further, since no stopper of the coolant channel is provided on the surface where the electronic parts are mounted, the coolant is prevented from flowing onto the surface of mounting the electronic parts.

Otherwise, the coolant would flow onto the surface of mounting the electronic parts in the event the coolant has leaked from a sealing portion between the stopper and the casing. Thus, the coolant will flow out of the switching power supply in the event of such leakage without flowing onto the surface of mounting the electronic parts.

Therefore, breakage or the like of the electronic parts would not be caused in the switching power supply.

(Seventh Embodiment)

Referring to FIGS. **12** to **14**, a seventh embodiment of the present disclosure is described. FIG. **12** is a plan view illustrating the switching power supply **1** according to the seventh embodiment. FIG. **13** is a vertical cross-sectional view taken along a C-C line of FIG. **12**. FIG. **14** is a vertical cross-sectional view taken along a D-D line of FIG. **12**.

In the seventh embodiment, the shapes of the casing **3** and the primary channel **50** have been changed. As shown in FIGS. **12** and **13**, a recess **300** is formed in an area where the electronic parts **2** are mounted.

As shown in FIG. **14**, the primary channel **50** has a semi-circular cross section perpendicular to the direction in which the coolant flows. Specifically, the primary channel **50** has a flat face **500***a* on the side near the electronic parts **2** and an arcuate face **500***b* on the side opposite to the flat face **500***a.*

Thus, the casing **3** has a reduced thickness d between the electronic parts **2** and the primary channel **50**. At the same time, the area of cooling is enlarged, in which area the electronic parts **2** are mounted, to thereby enhance heat dissipation of the electronic parts **2**.

Further, owing to the formation of the recess **300**, the space in the casing **3** can be efficiently used and thus the size of the switching power supply **1** is reduced. Although the cross-sectional shape of the primary channel **50** in the present embodiment is semi-circular, a different shape may be used, depending such as on the constraints imposed by heat-generating parts or other parts.

The remaining configuration is similar to the first embodiment.

Various embodiments of the present disclosure have been described above. As will be understood from the description provided above, the present disclosure brings about the advantages as set forth below.

In the present disclosure, a seat member and a casing are integrally formed, with a coolant channel being formed through the seat member. Thus, the number of parts is reduced in forming the coolant channel and the size of the casing is also reduced.

Specifically, taking the case, as a comparison, where the casing **92** (see FIG. **16**) and the channel cover **94** are assembled to form a coolant channel, the channel cover **94** and the bolts for fixing the channel cover to the casing **92** are not necessary in the present disclosure. Thus, the number of parts is reduced in the present disclosure.

Further, the female thread portions for screwing the bolts are not also necessary in the present disclosure. Thus, the size of the casing is reduced in the present disclosure.

Furthermore, the coolant channel is formed through the seat member that is integrated with the casing. Therefore, the casing has a smooth outline without a concavo-convex surface. Such a shape of the casing contributes to enhancing the degree of freedom in installing the switching power supply.

Also, additional members are not required to be assembled in forming the coolant channel. Specifically, for example, the step of connecting the channel cover **94** to the casing **92** (see FIG. **16**) can be omitted. Thus, the number of steps can be reduced in manufacturing the switching power supply.

It is favorable that the casing and the seat member are integrally formed by casting. Use of casting enables integrally manufacturing the casing and the seat member as well as the coolant channel, whereby the number of parts is reduced and the configuration is simplified.

As described above, according to the switching power supply of the present disclosure, the size, the number of parts and the number of steps of manufacture are all reduced.

What is claimed is:

1. A switching power supply comprising:

electronic parts that configure a switching circuit;

a casing that accommodates the electronic parts;

a protective cover that covers the causing;

a weakly cooled area formed unitarily with the causing for mounting the electronic parts;

a seat member formed protruding from the casing unitarily with the casing on which the electronic parts are mounted; and

a coolant channel formed penetrating through the seat member so as to be open at least at two positions of an outer wall surface of the casing;

wherein, coolant that flows through the coolant channel cools the electronic parts mounted on the seat member; and

a distance from the seat member to the protective cover is shorter that a distance from the weakly cooled area to the protective cover.

2. The switching power supply according to claim **1**, wherein

the coolant channel includes a primary channel formed through the seat member, and

a secondary channel extended in a direction of intersecting the primary channel for connection thereto, and the connection is established at a position between end portions of the primary channel, with one end of the secondary channel being open in an outer wall surface of the casing,

and wherein one end portion of the end portions of the primary channel is provided with a stopper so that the coolant flows from the other end portion to the secondary channel through the primary channel.

3. The switching power supply according to claim **1**, wherein

the coolant channel includes a primary channel formed through the seat member, and

a pair of secondary channels extended in a direction of intersecting the primary channel for connection thereto, and the connection is established at a position between end portions of the primary channel, with one end of the secondary channel being open in an outer wall surface of the casing,

and wherein each of the end portions of the primary channel is provided with a stopper so that the coolant flows from one of the secondary channel to the other one of the secondary channel through the primary channel.

4. The switching power supply according to claim **3**, wherein

the pair of secondary channels are extended in the same direction,

the primary channel has a first side face on a side to which the pair of secondary channels are connected, the first side face residing between the pair of secondary channels, and a second side face residing on an opposite side of the first side face with reference to the secondary channel on a downstream side,

the first side face coincides with the second side face regarding the position in a direction in which the secondary channels are extended.

5. The switching power supply according to claim **2**, wherein

a cross-sectional area of the secondary channel, which is perpendicular to a direction of flow of the coolant, is made smaller than that of the primary channel.

6. The switching power supply according to claim **2**, wherein

the seat member has major surfaces on both sides thereof with an interposition of the coolant channel,

different electronic parts are mounted on the major surfaces, and

the electronic part mounted on one of the major surface of the seat member configures a switching circuit, while the electronic part mounted on the other one of the major surface of the seat member configures another switching circuit.

7. The switching power supply according to claim **1**, wherein

the switching power supply further comprises:

a protective cover that covers the casing, and

a weakly cooled area formed unitarily with the casing for mounting the electronic parts,

and wherein amount of heat generated by the electronic parts mounted on the seat member is larger that of the electronic parts mounted on the weakly cooled area, and

a distance from the seat member to the protective cover is shorter that a distance from the weakly cooled area to the protective cover.

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